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STUDYING STUDENT STATISTICAL LITERACY IN STATISTICS LECTURES ON HIGHER EDUCATION USING GROUNDED THEORY APPROACH

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ABSTRACT

The purpose of this study was to obtain an overview of the student's Statistical Literacy model in Statistics learning in Higher Education. Researchers conducted an in-depth study of student statistical literacy, how they understand and apply statistics, how statistics are used as a tool for reliable data that can be trusted as scientific works. The research method uses qualitative research methods with a Grounded Theory approach. Participants involved in this study were 114 participants from several universities in West Java, Indonesia. The results of this study found a student statistical literacy model consisting of 2 dimensions and 5 elements. Dimensions of Statistical Knowledge: Descriptive Statistics, Inference Statistics, Statistical Communication and Statistical Reasoning. Attitude Dimensions: Confidence and Critical Attitude.

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1. INTRODUCTION

In the era of fast and easy digital information, statistical information is easy to obtain through digital media. Statistical information is always used by various institutions, such as: research and educational institutions, statistical institutions or bureaus, data information centers, and others. Many news stories from the mass media, research journals, and government agencies use statistical information to strengthen their argument and reliability. The data and statistical analysis used must be true and good, and meet reliability and have been tested in theory and practice (Bellinga & Gillebaart, 2018). The development of information technology triggers everyone to get fast-paced and valid information. No exception with statistical information. Almost all institutions in reporting their performance results use statistics because they are more concise and information dense. Therefore, many institutions hold statistical analysis training using statistical analysis software to improve their performance (Noha, 2013). The need to understand statistical information has been highlighted by various organizations in the United States, including the American Library Association. Despite the increasing need for teaching statistics, statistical education has historically been viewed by many students as difficult and unpleasant to learn, and by many teachers as a frustrating and unprofitable course. As more students enroll in introductory statistics courses, teachers are faced with many challenges in helping these students succeed in their study of statistics (Ben-Zvi & Garfield, 2004).

Understanding statistical information is not just knowing the average, standard deviation, graphs, etc. but must have statistical thinking skills such as understanding how the data was obtained. Statistical thinking involves understanding why and how statistical investigations are conducted and the ideas underlying statistical investigations. The foundation of statistical investigation rests on the assumption that many real situations cannot be assessed without proper data collection and analysis. Statistical thinking includes how to understand data, model, choose analytical methods, estimate probabilities, test hypotheses, make conclusions, understand the context of problems, criticize and evaluate the results of statistical analysis (Ben-Zvi & Garfield, 2004). Statistical models must capture elements of real situations; so that the resulting data will lead to the context of statistical knowledge (Cobb & Moore, 1997). The topics that can be taught to students for Students' Statistical Thinking and Reasoning are the topic of data distribution (Bakker & Gravemeijer, 2004), the concept of Average (Konold & Pollatsek, 2004), concepts of Variance and Covariance (Moritz, 2004; Reading & Shaughnessy, 2004), Normal Distribution (Batanero et al., 2004), Sample and Sample Distribution (Chance et al., 2004; Watson & Callingham, 2003).

Some of the problems in Statistics learning are summarized by Tishkovskaya and Lancaster (2012), namely: How to apply Statistics content in problem solving (Allen et al., 2010; Garfield, 1995), learning is carried out by teachers who do not understand Statistics (Meng, 2009; Smith & Staetsky, 2007; Verhoeven, 2006), anxiety and lack of interest in learning Statistics (Gal & Ginsburg, 1994; Garfield, 1995), difficulties for students of other disciplines to study probability theory and statistics (Garfield, 1995; Garfield & Ben-Zvi, 2007), weak knowledge of basic statistics and mathematical reasoning (Batanero et al., 1994; Garfield & Ahlgren, 1988).

From the problems above, statistical literacy is an urgent need for students to have. Statistical literacy is a basic ability that must be possessed by students so as not to cause misinterpretations and make wrong decisions. Improper representation of data will risk problems and journalists' misunderstandings about statistical issues in their academic press releases (Spiegelhalter & Riesch, 2008). In Indonesia, most people do not yet have awareness of the importance of statistical literacy, except for a small number of the academic community. Therefore, the Indonesian government includes literacy (including statistical literacy) into the national curriculum that must be taught to all students and students.

Based on the needs above, there needs to be a minimum competency of Statistical Literacy, especially for students as a scientific community who thinks scientifically based on valid data. The purpose of this study was to examine students' statistical literacy in depth in order to obtain a student statistical literacy model that is in accordance with the demands of today's era. For this purpose, the researcher uses a qualitative research method with a Grounded Theory approach.

2. METHOD

This study uses a qualitative research approach Grounded Theory (GT). The reason the researcher uses the GT approach is because in this approach the expected result is a theory (Glaser & Strauss, 1967). The basic principle of the GT approach is that there are three coding stages that can be developed by researchers (Creswell, 2014; Goulding, 1999), namely: Open Coding, Axial Coding and Selective Coding. The GT research procedure that the researcher developed is depicted in the flowchart diagram (see Figure 1).

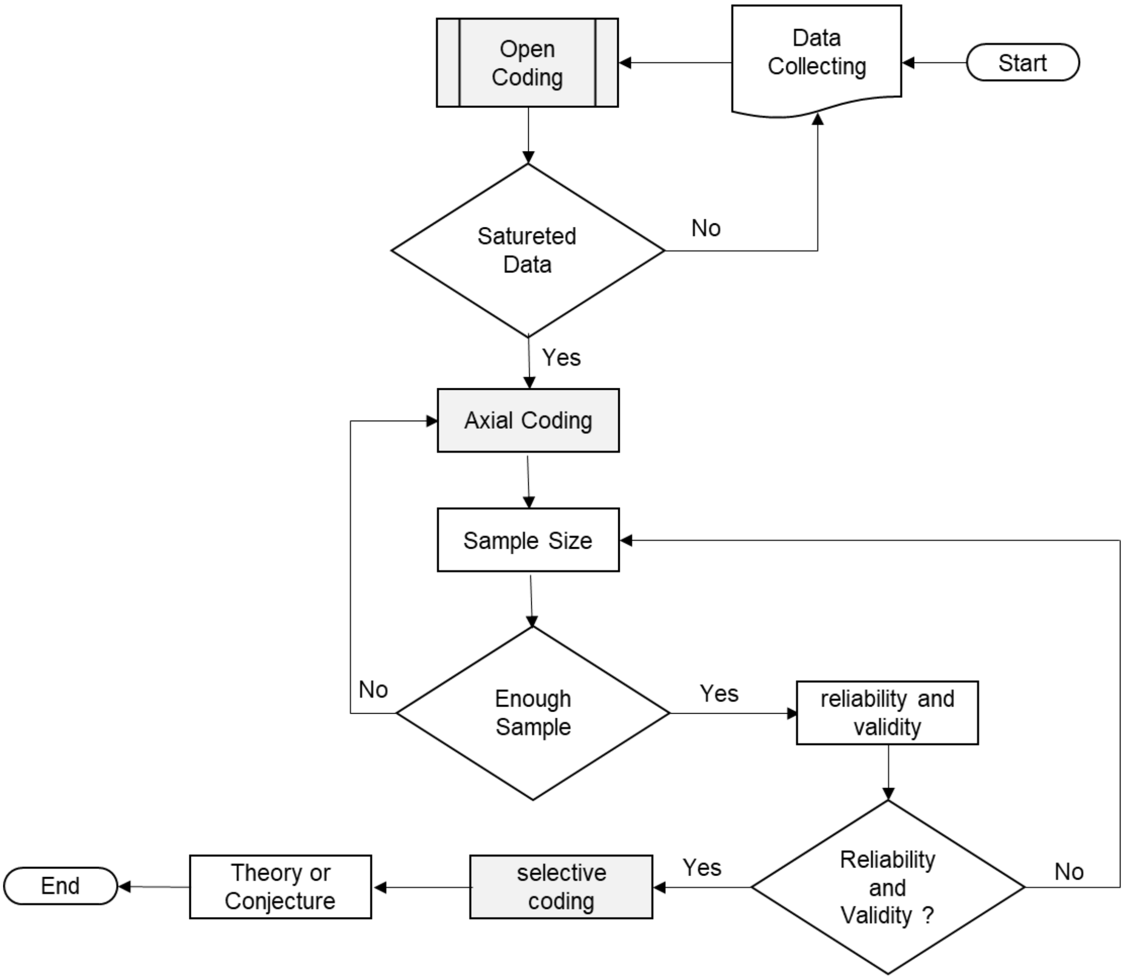


Figure 1. Flowchart of research methods and procedures GT approach

The participants involved in this research were 114 students at several universities with Education, Engineering, economics, and social study programs. Research locations in several universities in West Java, Indonesia. Data collection and analysis used open questionnaires, in-depth interviews, observations and learning videos. Open questionnaire data in the form of written participant answers, in-depth interview data in the form of transcripts of voice, observation and learning data in the form of videos.

3. RESULTS AND DISCUSSION

As is usual in qualitative research, the GT research instrument is the researcher himself (Charmaz, 2014; Creswell, 2014), this is different from quantitative research instruments. Theoretical sampling in GT research (generally qualitative research) is in the form of data in the form of interview transcripts, questionnaires, video transcripts, notes, public documents, diaries, participant journals, and researcher reflective notes. Researchers used Atlas.ti in qualitative data analysis.

3.1. Results

3.1.1. Data Collection and Open Coding

Data collection and open coding were carried out simultaneously until the data was saturated. The data are grouped based on the results of questionnaires, interviews, observations and learning videos. Open coding goes through stages: first, grouping words or phrases using word blob, counting words or phrases that often appear, and finally determining the right code. The results of the open coding of questionnaire data, interviews, observations and learning videos were as many as 145 codes from 301 quotations. One quote can be a sentence, one or more paragraphs. In open coding, researchers make memos to find out the relationship between codes and find core categories. This is important in the axial and selective coding stages. The relationship between open coding and axial coding is depicted in Figure 2.

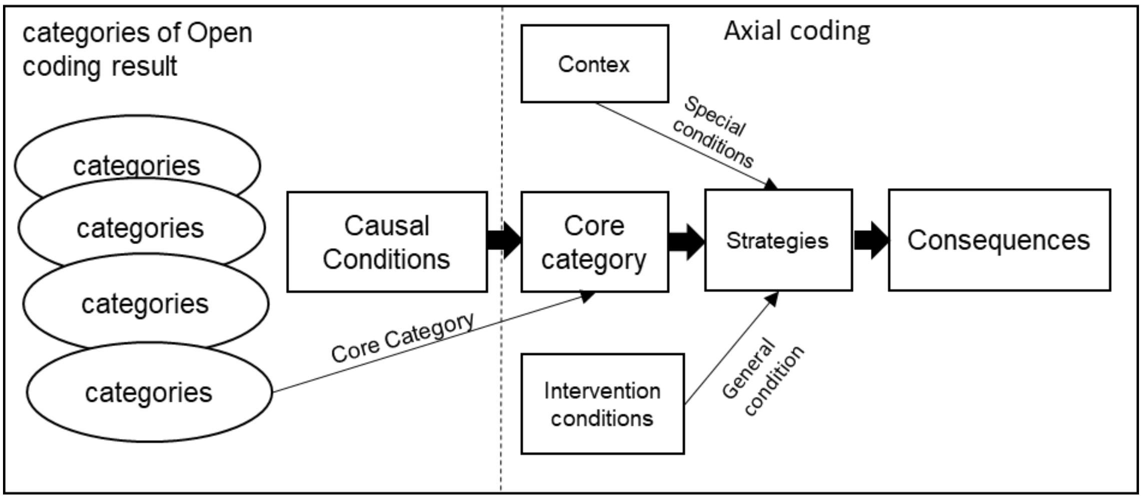


Figure 2. Relationship of open coding and axial coding

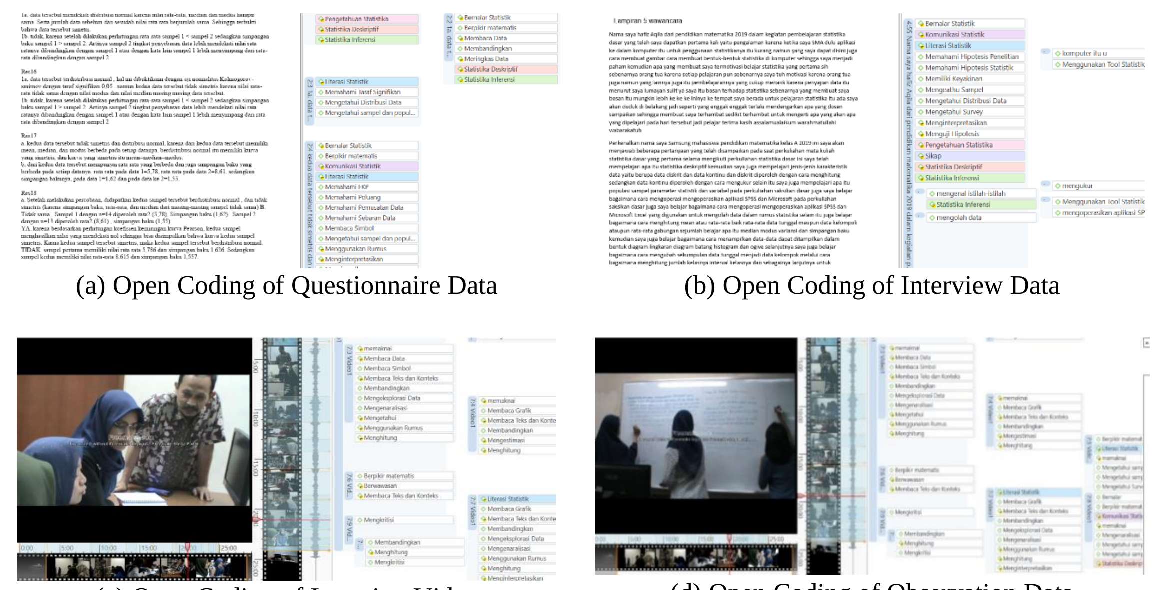
Causal conditions are categories of conditions that affect the core category. Context is the special conditions that affect the strategy. Core categories are the phenomenal ideas central to the process. The intervening conditions are the general conditions that influence the strategy. Strategies are specific actions or interactions that arise from core categories. Consequences are anything that arises with the implementation of strategies, strategies and consequences are used in the selective coding stage to find theories or research conjectures.

The results of the open coding show that Statistical Literacy is the core category, because this category always appears in every open coding and all categories are connected to it (see Figure 3). Therefore, the core category of open coding is Statistical Literacy. Other categories that often appear in open coding are Descriptive Statistics, Inference Statistics, Statistical Knowledge, Statistical Reasoning and Statistical Communication. Some important notes for researchers when open coding is:

"There is a strong relationship between Descriptive Statistics and Inference Statistics"

"Statistical Communication and Statistical Reasoning are indispensable in interpreting data contextually and in making conclusions."

"Students have high confidence when they understand statistics well."



(a) Open Coding of Questionnaire Data

(b) Open Coding of Interview Data

(c) Open Coding of Learning Video

(d) Open Coding of Observation Data

Figure 3. Open coding for all data

3.1.2. Axial Coding

Based on open coding and researcher notes, the core category “Statistical Literacy” was obtained. Based on the records, the results of the axial coding found 6 strategies consisting of 2 interventions: “Descriptive Statistics” and “Statistics Inference”, and 4 contexts: “Statistical Reasoning”, “Statistical Communication”, “Statistical Knowledge” and “Attitudes” (see Figure 4).

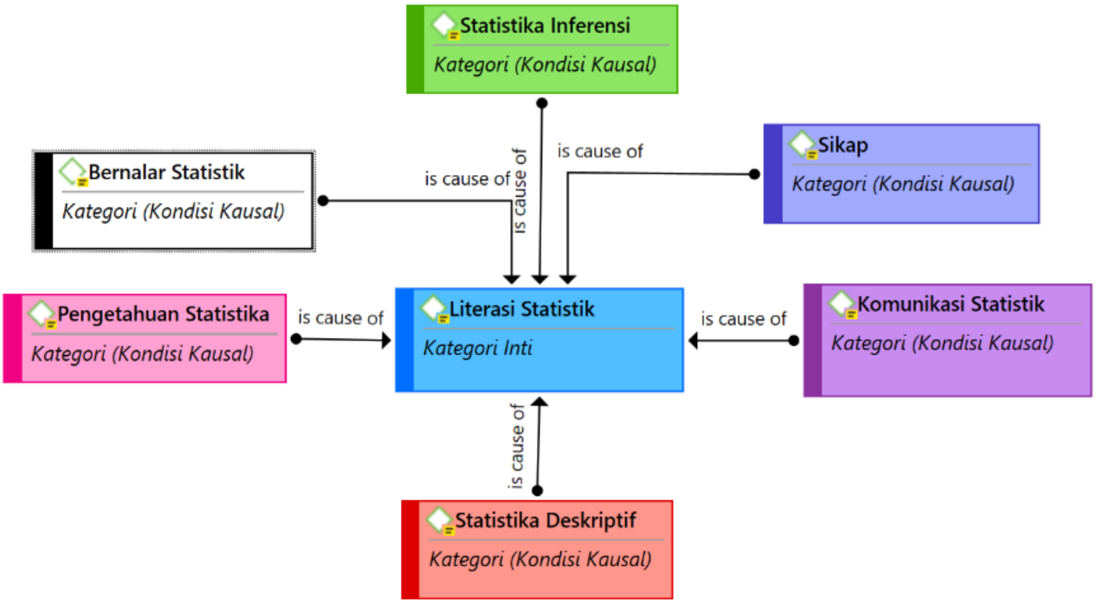


Figure 4. Axial coding with statistical literacy as the core category

Axial coding is the stage of comparing codes (Comparing Codes), comparing codes with each other and trying to understand how one code relates to another (Chametzky, 2016).

When comparing code and writing memos a pattern develops. Descriptive Statistics is the ability to read data, determine models and variables, calculate, analyze and interpret data. Reading data consists of reading tables and graphs, reading text and context. Calculating statistics based on statistical formulas and rules, students must have good basic counting skills. Analyzing and interpreting statistics are important things for students to understand before they make conclusions about the phenomena that occur. Philosophically Statistics is the applied science of how humans can interpret and predict statistical data inductively (De Finetti, 1989; Hotelling, 1951; Neyman, 1956)Generalizing a sample to a population inductively is called inductive inference. Therefore, students must understand Inference Statistics in making decisions and conclusions on the sample data. Inference Statistics is the ability to choose the right statistical test based on research hypotheses, comparing theoretical and empirical statistics, the ability to make decisions to accept or reject statistical hypotheses (H_0) and the ability to make appropriate conclusions based on inductive inference.

Statistical Literacy that must be possessed by students based on the researcher's notes is statistical communication, statistical knowledge, statistical reasoning, and attitudes. Statistical communication is the ability to read and interpret statistical language into a language that is understood by the general public. One of the weaknesses of students in studying statistics is statistical communication, this is due to the fact that most students view statistics as an abstract mathematical science, containing symbols and formulas. The ability to analyze and draw conclusions inductively requires good statistical reasoning skills. Statistical knowledge which includes understanding the context of the problem to be studied, understanding statistical terms and symbols is a sufficient requirement for students to have good statistical literacy. Finally, good statistical literacy will increase students' confidence and confidence in the results of their research. The attitude category consists of subcategories of self-confidence and critical attitude.

3.1.3. Validity and Reliability

Validity ensures that the statements made by the researcher reflect the reality he claims to be. Validity concerns correctness, while reliability ensures that research findings are reproducible and that there are no or almost minor external disturbances that contaminate the data. The relationship between reliability and validity is that the more unreliable a data is, the less likely it is that the researcher can draw valid conclusions from the data.

On the other hand, reliability does not always guarantee validity. Two coders with a high coefficient of relevance are objectively likely to be wrong if the two coders each have a unique perspective or have different academic disciplines (Krippendorff, 2004).

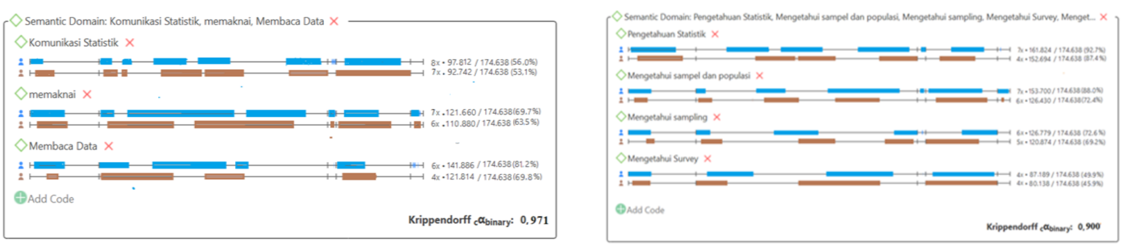
Validation and reliability in qualitative research are different from quantitative research, in qualitative research using interpretive concepts while in quantitative research using measurement theory. Data validation uses constant comparison analysis on triangulated data, in Grounded Theory constant comparison analysis emerges inductively from different data sources: questionnaire data, interview data, learning video data and observation results. The researcher uses the Atlas.ti program to see the consistency of the codes appearing in each different data (see Figure 5).

	Kuesioner 3 115	Video 2 20	Wawancara 2 102	Totals
Literasi Statistik 72	37 21,51%	23,61 13,73%	26,06 15,15%	86,67 16,80%
Komunikasi Statistika 3 47	15 8,72%	20,24 11,76%	26,06 15,15%	61,3 11,88%
Pengetahuan Statistik 8 40	23 13,37%	20,24 11,76%	7,82 4,55%	51,05 9,89%
Sikap 4 56	28 16,28%	23,61 13,73%	15,64 9,09%	67,24 13,03%
Statistika Deskriptif 9 106	30 17,44%	37,1 21,57%	75,58 43,94%	142,67 27,65%
Statistika Inferensi 7 81	39 22,67%	47,22 27,45%	20,85 12,12%	107,06 20,75%
Totals	172 100,00%	172 100,00%	172 100,00%	516 100,00%

Figure 5. Constant comparison analysis using atlas.ti

Constant comparison analysis using Code-Document Table analysis, data were normalized to equalize coding density for all documents. The learning and observation video data are combined in the video column, because they are both video data. The number in the cell indicates the frequency with which the same code appears in different documents, while the percentage indicates the relative frequency of the code in each document that has been normalized. Based on Figure 5 shows the codes appear constantly in each different data document.

The reliability test used the Inter-codes Agreement (ICA) test with the Krippendorff coefficient. The ICA test was used to find out that the coding by the researcher was not significantly different if the coding was done by someone else. The ICA test does not have to be tested for all the code, it is enough to take a representative sample using the Krippendorff coefficient. The researcher uses 2 semantic domains, namely: Statistical Communication and Statistical Knowledge. The size of the semantic domain is 174.638 words. The results of the ICA test analysis can be seen in Figure 6.



(a)
Domain Semantik Komunikasi Statistik, $\alpha_{CU} = 0.971$

(b)
Domain Semantik Pengetahuan Statistik, $\alpha_{CU} = 0.900$

Figure 6. ICA test using Krippendorff α coefficient

The proportion of Statistical Communication sample size for coder-1 and coder-2 was 56.0% and 53.1%, respectively. With a value of α_{CU}=0.971 and based on the Krippendorff significant level table with a significant level of 0.05, it can be concluded that the relevance of the agreement between coder-1 and coder-2 on the text has high reliability. 2, 92.2% and 87.4%, respectively. With the value of α_{CU}=0.900 and based on the Krippendorff significant level table with a significant level of 0.05, it can be concluded that the relevance of the agreement between coder-1 and coder-2 on the text has high reliability. not significantly different when performed by other coders.

3.1.3. Selective Coding

The final stage of data analysis using the GT approach is selective coding, which is to find theories or conjectures of students' statistical literacy models. At this stage the researcher focuses on core categories and categories and focuses on recurring problems and the categories associated with them (Glaser & Strauss, 1995). The results of the theory or conjecture found by researchers confirm the statistical philosophy and statistical literacy models found previously.

Consequences and strong relationships in general Statistical literacy as a core category is the ability to read and produce statistics of natural and social phenomena where students can represent these phenomena into statistical models and can analyze them. These abilities are part of the Descriptive Statistics category. A good understanding of Descriptive Statistics will have consequences for the ability to choose the right statistical test and generalize the sample to the population that is part of Inference Statistics. So, the general consequences of Statistical Literacy are Descriptive Statistics and Inference Statistics. These relationships were obtained consistently and repeatedly in each coding. An example of this relationship can be seen in Figure 7 in the axial coding and the notes made by the researcher. Descriptive statistical skills and Inference must also be supported by statistical reasoning skills, good statistical communication. The relationship is evident from each coding data source. Students who have good statistical reasoning and statistical communication skills tend to have good data interpretation, analysis and conclusion skills. For example, when they choose a statistical test that is appropriate for the sample to be tested, students who have the ability to communicate statistics and the ability to apply good statistical rules tend to have the ability to generalize the sample well. As they answered the questions in Figure 7.

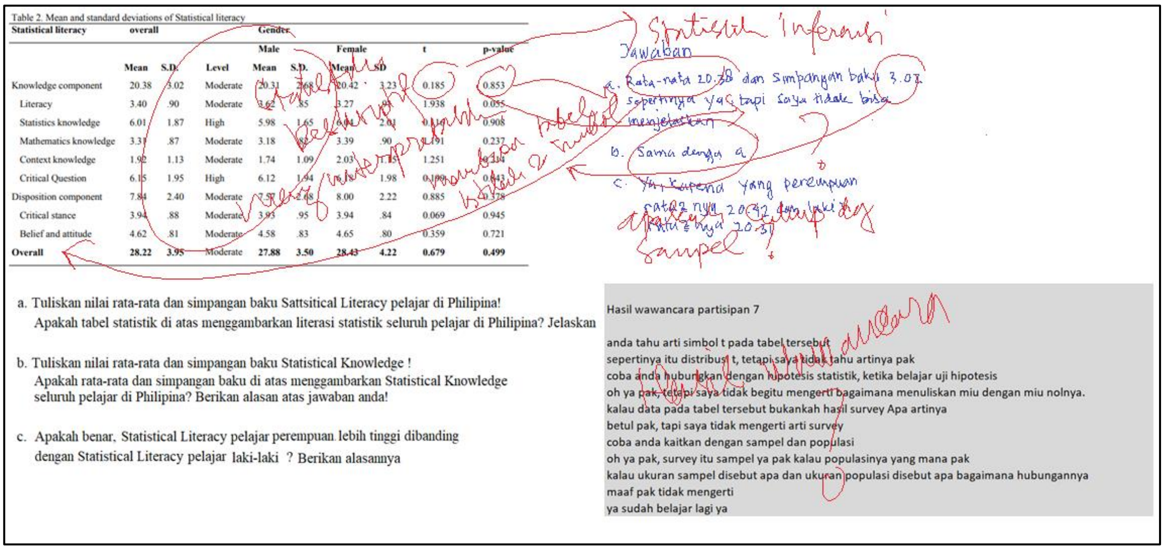


Table 2. Mean and standard deviations of Statistical literacy

Statistical literacy	overall			Gender					
				Male		Female		t	p-value
	Mean	S.D.	Level	Mean	S.D.	Mean	SD		
Knowledge component	20.38	3.02	Moderate	20.31	2.68	20.42	3.23	0.185	0.853
Literacy	3.40	.90	Moderate	3.62	.85	3.27	.94	1.938	0.055
Statistics knowledge	6.01	1.87	High	5.98	1.65	6.04	2.01	0.116	0.908
Mathematics knowledge	3.31	.87	Moderate	3.18	.82	3.39	.90	1.191	0.237
Context knowledge	1.92	1.13	Moderate	1.74	1.09	2.03	1.15	1.251	0.214
Critical Question	6.15	1.95	High	6.12	1.94	6.18	1.98	0.199	0.843
Disposition component	7.84	2.40	Moderate	7.57	2.68	8.00	2.22	0.885	0.378
Critical stance	3.94	.88	Moderate	3.93	.95	3.94	.84	0.069	0.945
Belief and attitude	4.62	.81	Moderate	4.58	.83	4.65	.80	0.359	0.721
Overall	**28.22**	**3.95**	Moderate	**27.88**	**3.50**	**28.43**	**4.22**	**0.679**	**0.499**

a. Tuliskan nilai rata-rata dan simpangan baku Sattsitical Literacy pelajar di Philipina!
Apakah tabel statistik di atas menggambarkan literasi statistik seluruh pelajar di Philipina? Jelaskan

b. Tuliskan nilai rata-rata dan simpangan baku Statistical Knowledge !
Apakah rata-rata dan simpangan baku di atas menggambarkan Statistical Knowledge seluruh pelajar di Philipina? Berikan alasan atas jawaban anda!

c. Apakah benar, Statistical Literacy pelajar perempuan lebih tinggi dibanding dengan Statistical Literacy pelajar laki-laki ? Berikan alasannya

Statistik Inferensi

Jawaban

a. Rata-rata 20.38 dan simpangan baku 3.02 sepertinya ya tapi saya tidak bisa menjelaskan

b. Sama dengan a

c. Ya, karena yang perempuan rata2 nya 20.42 dan laki2 rata2 nya 20.31

Hasil wawancara partisipan 7

anda tahu arti simbol t pada tabel tersebut
sepertinya itu distribusi t, tetapi saya tidak tahu artinya pak
coba anda hubungkan dengan hipotesis statistik, ketika belajar uji hipotesis
oh ya pak, tetapi saya tidak begitu mengerti bagaimana menuliskan miu dengan miu nolnya.
kalau data pada tabel tersebut bukankah hasil survey Apa artinya
betul pak, tapi saya tidak mengerti arti survey
coba anda kaitkan dengan sampel dan populasi
oh ya pak, survey itu sampel ya pak kalau populasinya yang mana pak
kalau ukuran sampel disebut apa dan ukuran populasi disebut apa bagaimana hubungannya
maaf pak tidak mengerti
ya sudah belajar lagi ya

Figure 7. The results of students' answers to statistical literacy skills

The relationship between Statistical Literacy and Descriptive Statistics and Inference Statistics when students read analysis of research data from International Journals. Students can replicate data analysis into different contexts. Students' critical ability and confidence in statistical information from various survey results encourage them to study more deeply in statistics. Therefore, the three categories of statistical reasoning, statistical communication and attitudes are factors that interfere with student statistical literacy.

3.2. Discussion

Based on the results of selective coding, statistical literacy can be grouped into 2 groups called dimensions (Gal, 2004; Sharma, 2017), namely: Statistical Knowledge and Attitudes. Elements of Statistical Knowledge are Descriptive Statistics, Inference Statistics, Statistical Reasoning and Statistical Communication. While the elements of attitude consist of Self-Confidence and Critical Attitude (see Figure 8).

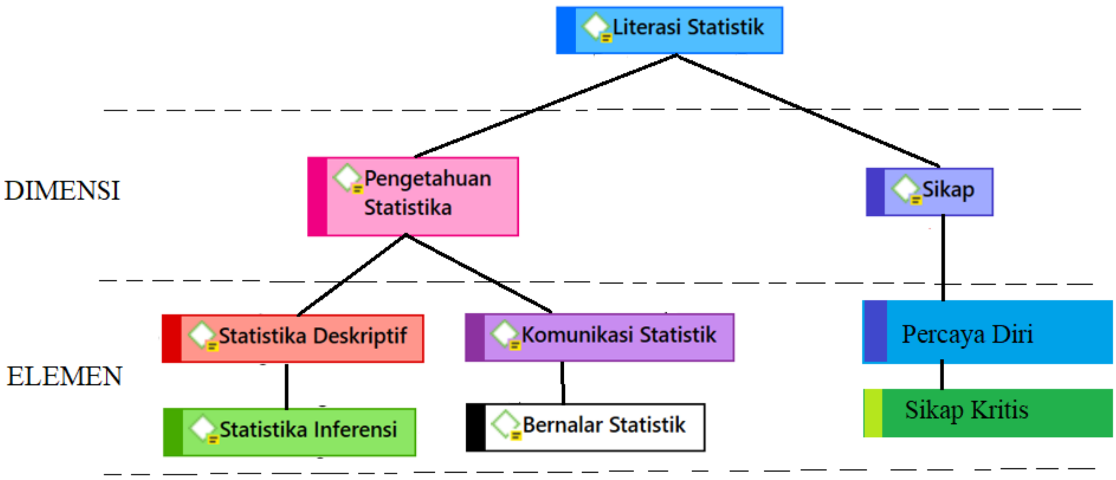


Figure 8. Student statistical literacy model

The relationships between the categories are grouped in Table 1 which describes the elements of each dimension and their competencies. The competencies of each element are derived from the consequences of applying statistical literacy strategies, where the grouping of competencies is based on repeated relationships during selective coding. Atlas.ti helps researchers to see these relationships by using query analysis.

Table 1. Dimensions, elements and competencies of student statistical literacy models

Dimension	Element	Competence
Statistical Knowledge	Descriptive Statistics	The ability to read statistical information and the ability to produce statistics correctly, determine statistics (mean, median, standard deviation, frequency tables, diagrams, etc.), determine sampling techniques.
	Inference Statistics	Ability to make statistical hypotheses and research hypotheses, ability to test hypotheses, determine alpha, make correct decisions and conclusions.
	Statistical Communication	The ability to communicate statistical information contextually, the ability to communicate the results of data analysis (hypothesis testing) contextually. Ability to use statistical tools.
	Statistical Reasoning	Ability to apply statistical rules correctly and logically, ability to relate statistical concepts to mathematics.

Dimension	Element	Competence
Attitudes	Self-Confidence	The ability to argue correctly on the reliability of the data, and the ability to argue correctly on the results of his research.
	Critical Attitude	The ability to analyze statistical information, and the ability to criticize statistical information with correct arguments.

Based on the results of selective coding, a statistical literacy model was obtained for students: Statistical Literacy has two domains, namely: Statistical Knowledge and Attitudes. The Statistical Knowledge Domain has 4 elements: Descriptive Statistics, Inference Statistics, Statistical Communication, and Statistical Reasoning. The Attitude element has 2 elements: Self-Confidence and Critical Attitude (see Figure 8). The respective competencies of the elements are described in Table 1.

4. CONCLUSION

Statistical literacy is the ability to model natural and social phenomena into statistical models to determine population characteristics based on generalized sample data analysis so that they can describe the population or predict phenomena that will occur in the future. Philosophically Statistics use inductive inference in its proof. Therefore, describing the character of the population or predicting future phenomena based on samples using inductive inference.

Statistical Literacy Students in general are the ability to interpret and criticize statistical information produced by others and the ability to produce statistics as a tool to explain the reliability of their scientific reports. Along with the development of IT technology, the ability to use statistical tools is part of statistical literacy that students must have.

The literacy model found in this study is almost similar to the Gal model (Gal, 2004) the difference is in the elements of descriptive statistics and inference statistics. In the knowledge dimension of the Gal model, most of it is spread on the elements of Descriptive Statistics and Inference Statistics, while the disposition dimension is mostly on the attitude elements and Inferential Statistics elements. Gal does not include the ability to use statistical tools in the model, it is possible that at that time statistical tools had not developed rapidly at this time. This model does not find any statistical literacy level as the model found by Watson and Callingham (Watson & Callingham, 2003; Watson, 2004). The Student Statistical Literacy Model in this study can be an alternative for teachers and trainers in designing Statistics learning designs in Universities or in Statistics course institutions.

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